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(54) **AIR-EXHAUST MIXING APPARATUS**

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F02B 47/08 (2006.01)
F02M 25/07 (2006.01)

(52) **U.S. Cl.** **123/568.17**; 123/568.11; 60/605.2

(58) **Field of Classification Search** ..... 123/568.11, 123/568.17, 585, 590, 306; 60/605.1, 605.2; 336/163.1, 163.2, 165.1, 165.2; 137/561 A
See application file for complete search history.

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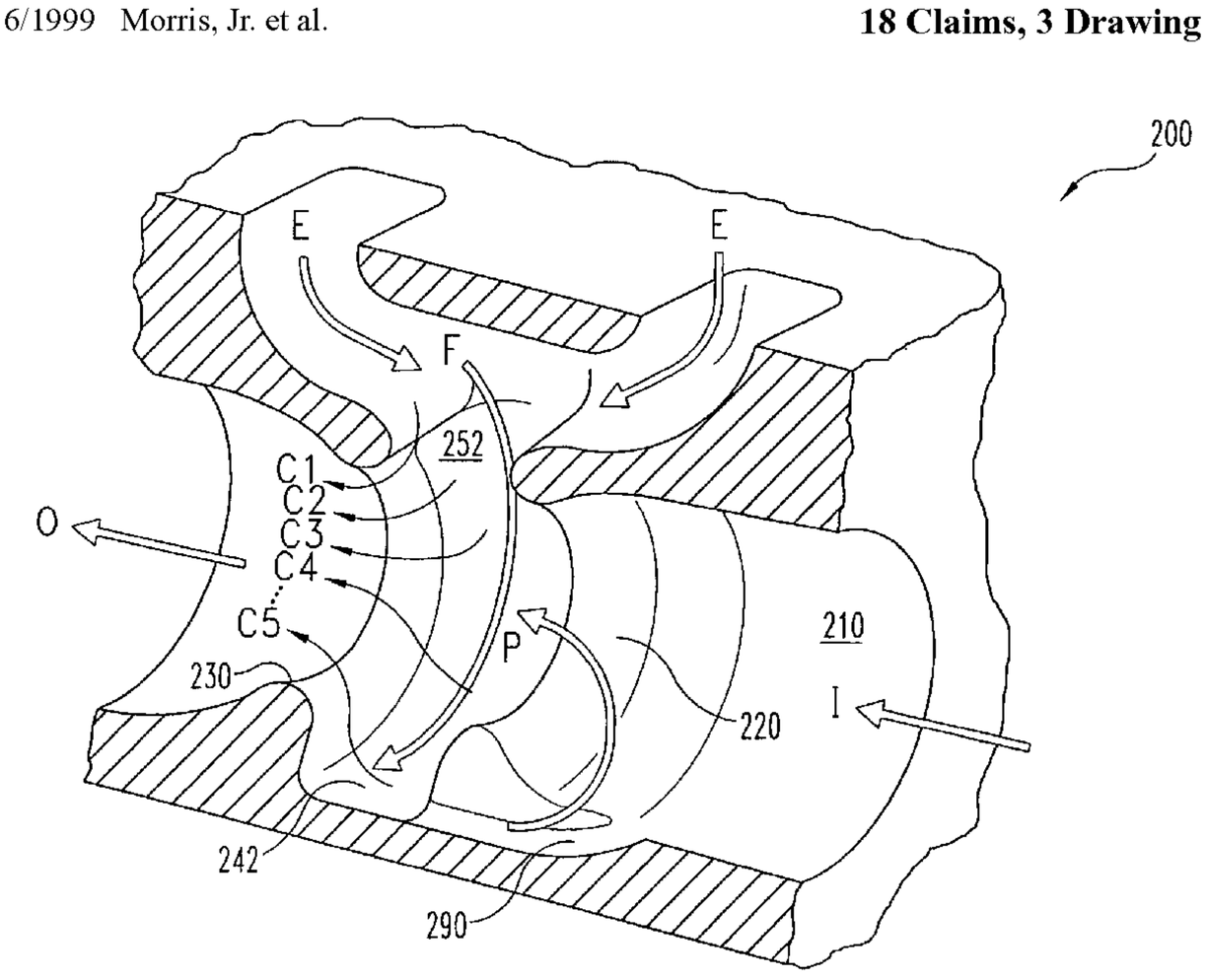
(57) **ABSTRACT**

One embodiment is an apparatus including an air-exhaust mixing passageway, a first lip extending into the passageway, a second lip extending into the passageway, a valley intermediate the first lip and the second lip, and an exhaust inlet aperture in flow communication with the flow channel.

18 Claims, 3 Drawing Sheets



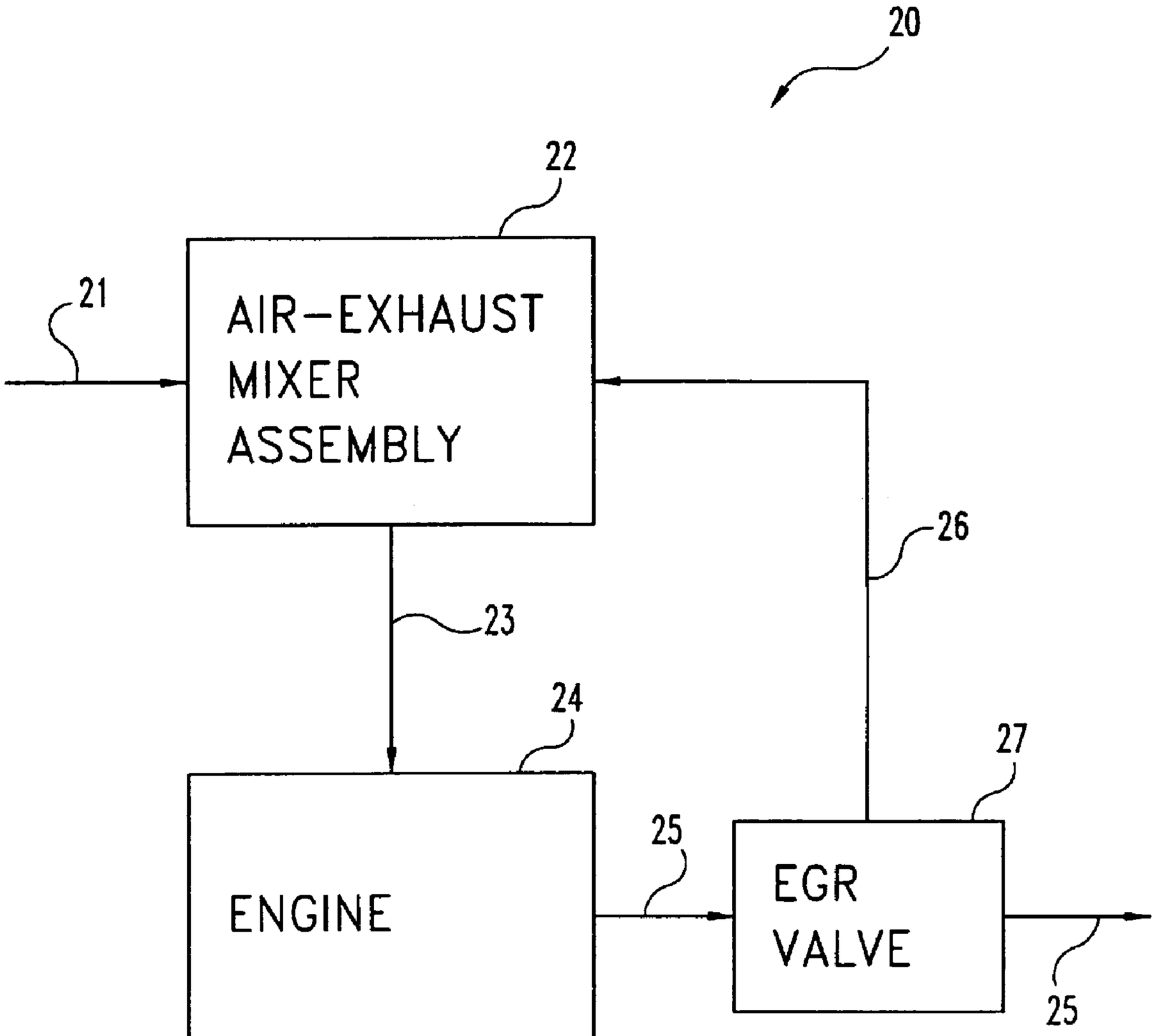

20
22
21
AIR–EXHAUST
MIXER
ASSEMBLY
26
23
24
27
25
ENGINE
EGR
VALVE
25

Fig. 1

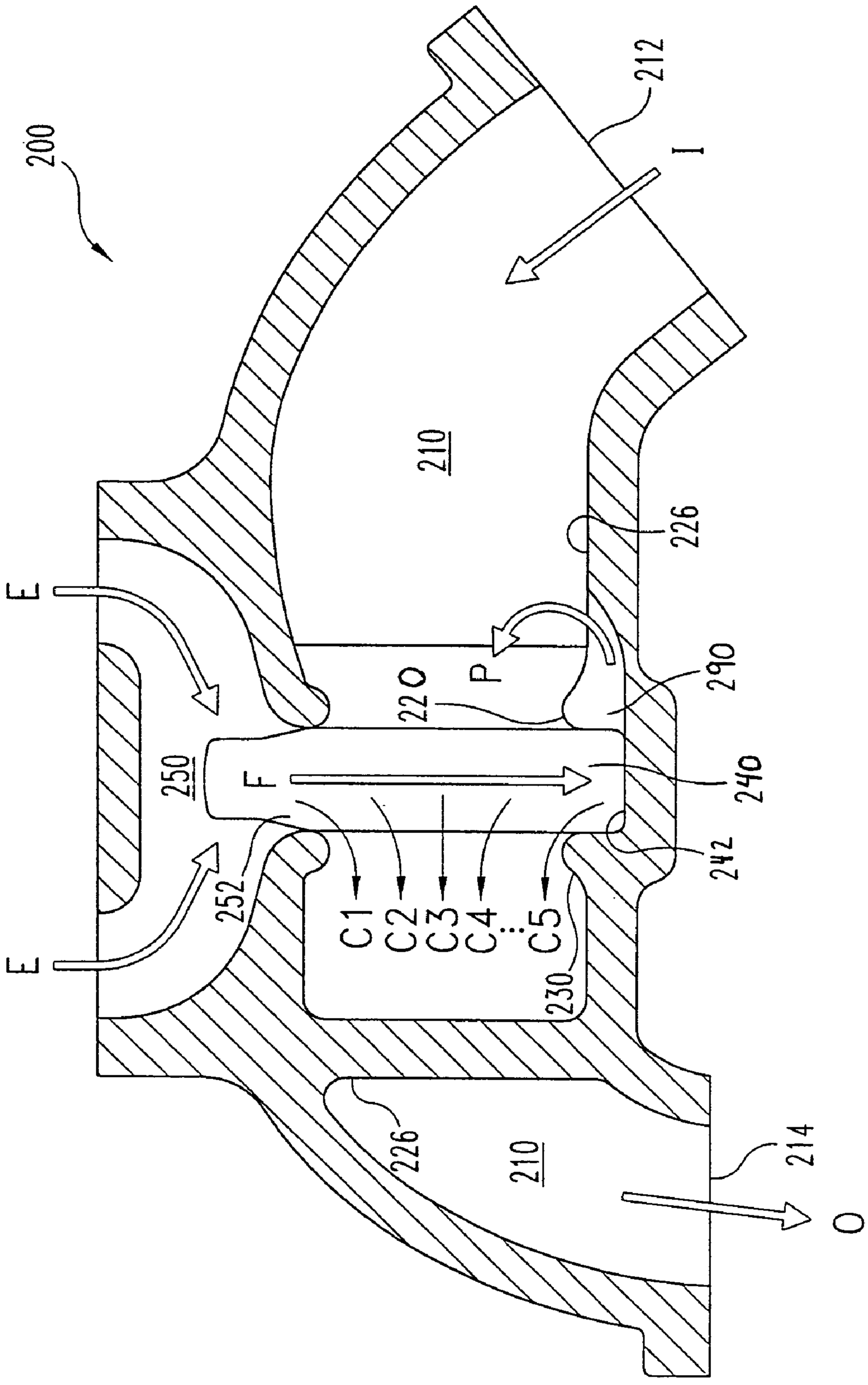

200
212
I
210
E
E
220
P
290
250
F
240
252
C1
C2
C3
C4
C5
242
230
226
226
210
214
O

Fig. 2

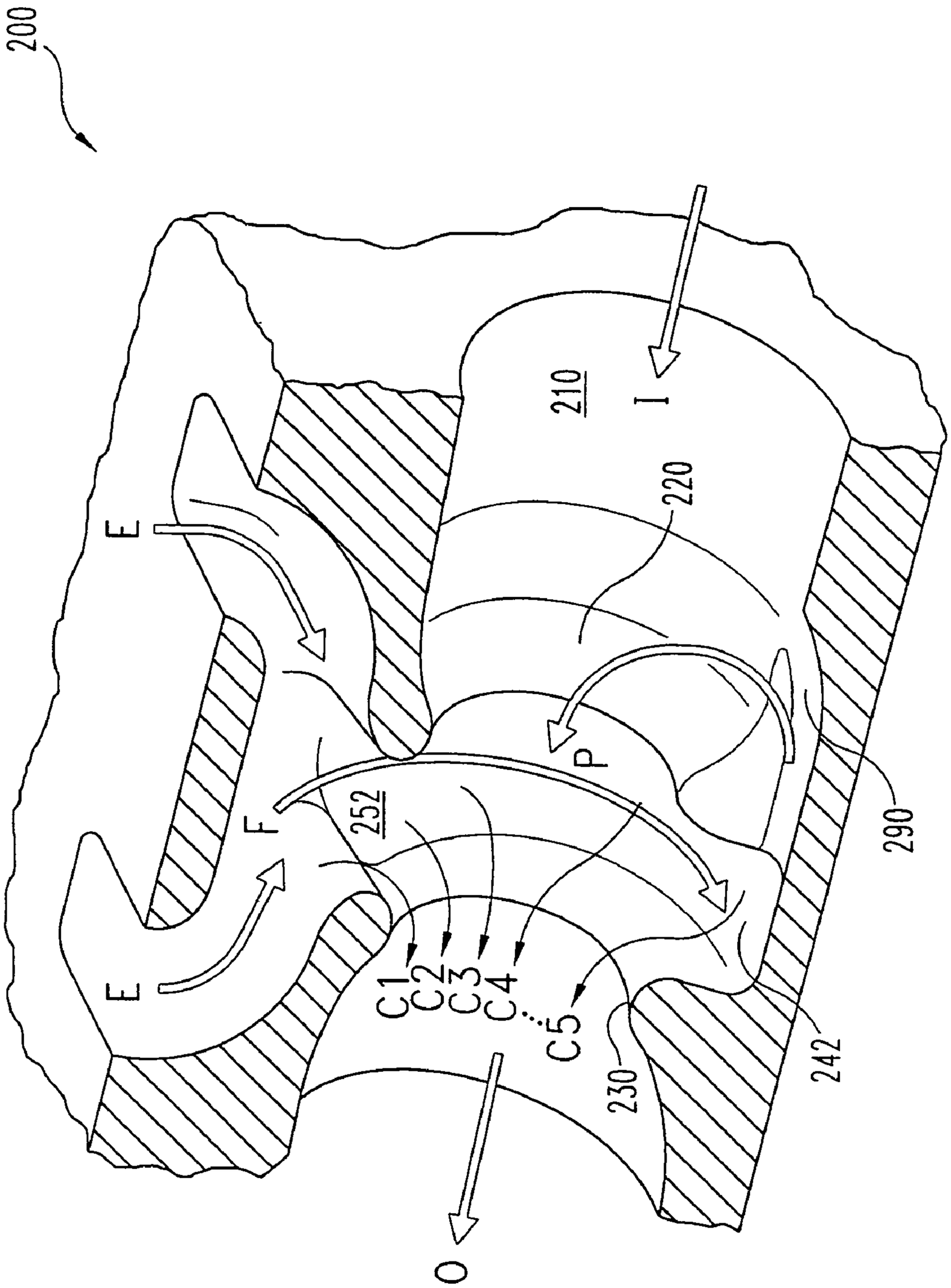


Fig. 3

AIR-EXHAUST MIXING APPARATUS

RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 60/876,637 filed Dec. 22, 2006, which is incorporated herein by reference.

TECHNICAL FIELD

The technical field generally relates to air-exhaust mixing apparatuses.

BACKGROUND

Exhaust gas recirculation (EGR) is used to reduce pollution generated by engines and other combustion devices. With EGR, a portion of the exhaust generated by a combustion reaction is mixed with intake air in order to reduce the amount of pollutants expelled into the atmosphere. Inadequate mixing of the air and exhaust can lead to the creation of increased concentrations of pollutants in the exhaust gas. Various attempts to provide adequate mixing of air and exhaust suffer from a number of drawbacks, disadvantages and shortcomings. There remains a longstanding need for air-exhaust mixing apparatuses which address these issues.

SUMMARY

One embodiment is an apparatus including an air-exhaust mixing passageway, a first lip extending into the passageway, a second lip extending into the passageway, a valley intermediate the first lip and the second lip, and an exhaust inlet aperture in flow communication with the valley. Further embodiments, forms, objects, features, advantages, aspects, embodiments and benefits shall become apparent from the following descriptions, drawings, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of one embodiment of an EGR system.

FIG. **2** is a side sectional view of one embodiment of an air-exhaust mixer.

FIG. **3** is a perspective sectional view of the air-exhaust mixer of FIG. **2**.

DETAILED DESCRIPTION

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

With reference to FIG. **1**, an EGR system **20** is illustrated in schematic form. System **20** includes an air intake **21**, an air-exhaust mixer **22**, engine intake manifold **23**, engine **24**, exhaust conduit **25**, EGR flow coupling **26**, and EGR valve **27**. Air intake **21** and EGR conduit **26** are flow coupled to air-exhaust mixer **22**. Air-exhaust mixer **22** is flow coupled to engine **24** through engine intake manifold **23**. Engine **24** is flow coupled to EGR valve **27** through exhaust conduit **25**, and EGR valve **27** is flow coupled to air-exhaust mixer **22** through EGR flow coupling **26**. In one embodiment, EGR flow coupling **26** involves the attachment of an EGR valve output to an air-exhaust mixing apparatus. In other embodiments, EGR flow coupling **26** may include one or more intermediate flow passages, conduits or other structures.

In system **20**, air is supplied through air intake **21**. The supplied air can be filtered, unfiltered, and/or conditioned in other manners. In one embodiment, ambient air is pressurized and sent through an air cooler (not illustrated) before being sent to the air intake **21**. Pressurization can be accomplished, for example, by a turbocharger or supercharger. EGR valve **27** selectably recirculates a portion of exhaust from the engine **24** to air-exhaust mixer **22**. Exhaust which is not recirculated by EGR valve **27** continues through exhaust conduit **25**. In addition, exhaust in system **20** may be utilized to drive a turbocharger and may also be treated by exhaust aftertreatment systems to reduce the emission of pollutants. Air-exhaust mixer assembly **22** mixes exhaust received from EGR valve **27** with air from air intake **21**. The mixture is then supplied to engine **24** through engine intake manifold **23**. In a preferred embodiment, engine **24** is a turbocharged diesel engine. It should be understood that a variety of other types of engines and combustion devices are contemplated by additional embodiments including non-turbocharged diesel engines as well as engines which combust fuels other than diesel.

With reference to FIGS. **2** and **3** there is illustrated one embodiment of an air-exhaust mixer **200**. Mixer **200** includes a flow passageway **210** which receives an air flow at intake **212** as indicated by arrow I. As air flow proceeds through flow passageway **210** it encounters lips **220** and **230** which extend into flow passageway **210** to provide a constriction which increases the speed and decreases the pressure of airflow. Valley **240** is positioned intermediate lips **220** and **230** and is substantially open to the region of flow passageway **210** intermediate lips **220** and **230**.

As illustrated in FIG. **2**, valley **240** has a generally annular shape with a substantially constant width and depth, and the depth of the bottom surface **242** of valley **240** is greater than that of surface **226** of flow passage **210**. Other embodiments include flow channels which taper from a maximum width near aperture **252** to a minimum width, taper from a maximum depth near aperture **252** to a minimum depth, or both. Further embodiments contemplate flow channels with greater or lesser depths than the illustrated embodiment. Additional embodiments contemplate flow channels which extend over only a portion of the interior of flow passage **210**. Lips **220** and **230** could also extend over only a portion of the interior of flow passage **210** or could have varying heights or widths, though in the illustrated embodiment they have substantially constant dimensions. In a preferred embodiment, lips **220** and **230** and valley **240** are integral portions of a casting. In a most preferred embodiment, substantially the entire body of mixer **200** is a single piece casting. Other embodiments contemplate discrete components which are coupled together to provide lips and an intermediate valley.

Mixer **200** includes exhaust intake passage **250** which receives exhaust flow from an exhaust source, such as an EGR valve, as indicated by arrows E. The received exhaust flows through exhaust intake passage **250** to exhaust intake aperture **252** and then to valley **240**. Exhaust flows through valley **240** as illustrated by arrow F. As indicated with arrows C**1**, C**2**, C**3**, C**4**, and C**5** exhaust flow exits valley **240** and mixes with the air flow in flow passageway **210**. As indicated by the ellipsis, arrows C**1**, C**2**, C**3**, C**4**, and C**5** are not exclusive routes, rather the mixing flow of exhaust from channel **240** can be essentially continuous along channel **240**. When a lower amount of

exhaust is provided to valley **240**, exhaust flow valley **240** could be completed before exhaust reaches the farthest extent of valley **240**.

A preferred embodiment of mixer **200** includes condensation slot **290**. Moisture and/or particulate which collects in valley **240** can drain via slot **290** to avoid accumulation in valley **240** as well as potential attendant effects such as corrosion. As indicated by arrow P, matter collected in slot **290** is also mixed into the air flow I through passageway **210**. In other embodiments, condensation slot **290** is not present and lip **220** continues through the region in which it is defined.

The air-exhaust mixture continues to flow through passageway **210**. In a preferred embodiment the mixture flows past central member **226** which is positioned in flow passageway **210**. In other embodiments, central member **226** is not present. The exhaust-air mixture then flows to outlet **214** where it is outlet from mixer **200** as indicated by arrow O. As mentioned above, outlet **214** can be flow coupled to an air intake of an internal combustion engine, or to an air intake manifold.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

What is claimed is:

1. An apparatus comprising:
an air-exhaust mixing passageway;
a first lip extending into the passageway;
a second lip extending into the passageway;
a valley intermediate the first lip and the second lip; and
an exhaust inlet aperture in flow communication with the valley;
wherein the valley extends intermediate the first lip and the second lip and is substantially open to the air-exhaust mixing passageway and substantially free of overhang by the first lip and the second lip.

2. The apparatus of claim **1** further comprising an EGR valve in flow communication with the exhaust inlet aperture.

3. The apparatus of claim **1** wherein said valley has a substantially uniform width.

4. The apparatus of claim **1** wherein said valley has substantially uniform dimensions.

5. The apparatus of claim **1** wherein the first lip has a first lip outer surface facing the passageway and being generally curved in longitudinal section, and the second lip has a second lip outer surface facing the passageway and being generally curved in longitudinal section.

6. The apparatus of claim **1** further comprising a condensation slot defined in the passageway.

7. The apparatus of claim **1** wherein the first lip, the second lip, and the valley are integral to a casting.

8. An apparatus comprising:
a flow passageway;
a first curved lip extending into the passageway in a substantially axial direction;
a second curved lip extending into the passageway in a substantially axial direction;
a valley intermediate the first curved lip and the second curved lip;
an exhaust inlet in flow communication with the valley; and
a condensation slot defined in the passageway and interrupting the second curve lip;
wherein the valley extends intermediate the first lip and the second lip and is open to the flow passageway substantially uncovered by the first lip and the second lip.

9. The apparatus of claim **8** wherein the first curved lip, the second curved lip and the valley comprise an integrally cast flow passage constriction.

10. The apparatus of claim **8** wherein the valley defines an interior circumferential surface of the passageway having substantially constant dimensions about its circumference.

11. The apparatus of claim **8** wherein the flow passageway is coupled to an internal combustion engine.

12. The apparatus of claim **8** wherein the flow passageway includes an inlet and an outlet, the inlet is flow coupled to a source of compressed air, and the outlet is flow coupled to an engine intake manifold.

13. An apparatus comprising:
an air-exhaust mixer casting defining a passageway including an inlet and an outlet;
an interior surface of said casting extending radially inwardly in a first region to define a first constriction, radially outwardly in a second region to define a recess, and radially inwardly in a third region to define a second constriction, the recess being in flow communication with a source of exhaust; and wherein the recess is substantially open to the passageway and substantially uncovered by overhanging structure.

14. The apparatus of claim **13** wherein the source of exhaust is an EGR valve.

15. The apparatus of claim **13** wherein the interior surface defines a condensation slot in flow communication with the recess.

16. The apparatus of claim **13** wherein the inlet is in flow communication with a turbocharger output.

17. The apparatus of claim **13** wherein the recess is open to a region of the passageway intermediate the first constriction and the second constriction.

18. The apparatus of claim **13** wherein the outlet is in flow communication with an internal combustion engine air intake.

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